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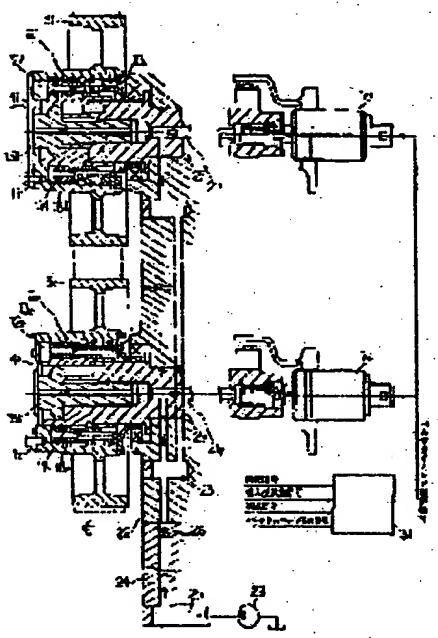
(54) VARIABLE VALVE TIMING DEVICE FOR ENGINE

(57)Abstract:
PURPOSE: To stabilize combustion and reduce fuel consumption by delaying opening/closing timings of an intake valve while advancing an exhaust valveduring low speed and low load operation time, advancing the opening/ closing timings of both the intake valve and the exhaust valve during low speed and high load operation time, and delaying the opening/closing timing of both the intake valve and the exhaust valve during high speed operation time.
CONSTITUTION: Valve timing mechanisms 1i, 1e are arranged between cam shafts 2i, 2e and cam pulleys 3i, 3e, while opening/closing timings of an exhaust valve is independently varied while varying phase angles. The valve timing adjust mechanism 1i of an intake valve is, for instance, provided with an inner housing 4i, an outer housing, a helical gear 6i, and a spline 17i. With the engagement thereof, a positional angle of the cam shaft 2i is varied in a rotational direction in respect to the cam pulley 3i. Such driving is performed by opening/ closing of a solenoid valve 7i which is controlled according to an operation condition by means of a control unit 31, with a hydraulic pressure in a hydraulic chamber 12i being varied. The same is true for the valve timing mechanism 1e of the exhaust valve.



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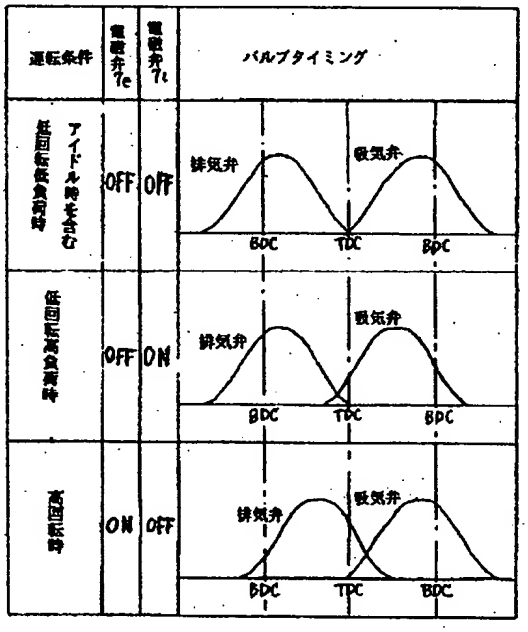
(54)【発明の名称】エンジンの可変バルブタイミング装置

(57)【要約】
【目的】　クランクシャフトに対するカムシャフトの位相角を変えるバルブタイミング調整機構を用いて、吸排気のタイミングを適正に制御する装置を提供する。
【構成】　クランクシャフトに対する吸気側カムシャフトと排気側カムシャフトの位相角を独立して変えるバルブタイミング調整機構を備え、コントロールユニットは、低回転低負荷時に吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を進ませ、低回転高負荷時に吸気弁の開閉時期を進ませるとともに、排気弁の開閉時期を進ませ、高回転時に吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を遅らせるようにバルブタイミング調整機構を駆動する構成とする。



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【特許請求の範囲】

【請求項１】　吸気弁を開閉駆動する吸気側カムシャフトと、排気弁を開閉駆動する排気側カムシャフトと、クランクシャフトに対する吸気側カムシャフトと排気側カムシャフトの位相角を独立して変えるバルブタイミング調整機構と、エンジンの運転条件を検出する手段と、エンジンの運転条件に応じてバルブタイミング調整機構を駆動する制御手段とを備えたエンジンの可変バルブタイミング装置にあって、制御手段は、低回転低負荷時に吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を進ませ、低回転高負荷時に吸気弁の開閉時期を進ませるとともに、排気弁の開閉時期を進ませ、高回転時に吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を遅らせるようにバルブタイミング調整機構を駆動する構成としたことを特徴とするエンジンの可変バルブタイミング装置。

【請求項２】　バルブタイミング調整機構を、クランクシャフトに対する吸気側カムシャフトの位相角の最大変位量を、排気側カムシャフトの位相角の最大変位量より小さく設定したことを特徴とする請求項１記載のエンジンの可変バルブタイミング装置。

【請求項３】　クランクシャフトに対する吸気側カムシャフトの位相角を油圧の上昇に応動して吸気弁の開閉時期が進む方向に変える吸気側油圧アクチュエータと、その非通電時に吸気側油圧アクチュエータに導かれる油圧を低下させる吸気側電磁弁と、クランクシャフトに対する排気側カムシャフトの位相角を油圧の上昇に応動して排気弁の開閉時期が遅れる方向に変える排気側油圧アクチュエータと、その非通電時に排気側油圧アクチュエータに導かれる油圧を低下させる排気側電磁弁とを備えたことを特徴とする請求項１記載のエンジンの可変バルブタイミング装置。

【請求項４】　低回転高負荷時から高回転時に変わる運転条件で、吸気弁の開閉時期を切換えた後に排気弁の開閉時期を切換える制御手段を備えたことを特徴とする請求項３記載のエンジンの可変バルブタイミング装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、クランクシャフトに対するカムシャフトの位相角を変えて、吸・排気弁の開閉時期をエンジン運転条件に応じて制御する可変バルブタイミング装置に関するものである。

【０００２】

【従来の技術およびその課題】この種の可変バルブタイミング装置として、例えば実開平２－７２３０５号公報にも見られるように、カムプーリとカムシャフトを油圧に応動するヘリカルギアを介して連結し、ヘリカルギアに作用する油圧力をエンジン運転状態に応じて制御することにより、ヘリカルギアを回転軸方向に移動させ、クランクシャフトとカムシャフトを相対回転させるバルブタイミング調整機構を備えるものがある。

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【０００３】ところが、従来はこのようなバルブタイミング調整機構が吸気側カムシャフトのみに設けられ、低回転低負荷時にバルブオーバラップを小さくすることにより、残留ガス率を低下させて燃焼を安定させる一方、低回転高負荷時に吸気弁の開閉時期を早めることにより、シリンダに吸入された混合気が吸入行程の下死点付近で吸気ポートに吐き出されることを抑制して、吸気充填効率を高めるようになっている。

【０００４】しかしながら、このように吸気弁の開閉時期のみを調整する装置では、例えば、低回転高負荷時に吸気弁の閉時期を早めるため、開閉時期を進ませるとバルブオーバラップが大きくなりすぎて、残留ガス率が増大して燃焼性が損なわれる。また、高回転時にバルブオーバラップを大きくしつつ、吸気弁の開閉時期を遅らせることが不可能でるため、十分な出力が得られないという問題点があった。

【０００５】また、従来から、エンジン運転条件に応じて複数のカムを選択的に切換える弁作動調整機構を備えて、吸排気のタイミングあるいは吸排気量を制御する装置が知られているが、この場合各気筒の吸・排気弁に対応してカムを切換える弁作動調整機構を設けなければならず、コストアップを招くという問題点があった(例えば特開昭６３－１６７０１６号公報、特開昭６３－５７８０５号公報等参照)。

【０００６】本発明は上記の問題点に着目し、クランクシャフトに対するカムシャフトの位相角を変えるバルブタイミング調整機構を用いて、吸排気のタイミングを制御する装置を提供することを目的とする。

【０００７】

【課題を解決するための手段】本発明は、吸気弁を開閉駆動する吸気側カムシャフトと、排気弁を開閉駆動する排気側カムシャフトと、クランクシャフトに対する吸気側カムシャフトと排気側カムシャフトの位相角を独立して変えるバルブタイミング調整機構と、エンジンの運転条件を検出する手段と、エンジンの運転条件に応じてバルブタイミング調整機構を駆動する制御手段とを備えたエンジンの可変バルブタイミング装置にあって、制御手段は、低回転低負荷時に吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を進ませ、低回転高負荷時に吸気弁の開閉時期を進ませるとともに、排気弁の開閉時期を進ませ、高回転時に吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を遅らせるようにバルブタイミング調整機構を駆動する構成とする。

【０００８】請求項２記載の発明は、バルブタイミング調整機構を、クランクシャフトに対する吸気側カムシャフトの位相角の最大変位量を、排気側カムシャフトの位相角の最大変位量より小さく設定する。

【０００９】請求項３記載の発明は、クランクシャフトに対する吸気側カムシャフトの位相角を油圧の上昇に応

動して吸気弁の開閉時期が進む方向に変える吸気側油圧アクチュエータと、その非通電時に吸気側油圧アクチュエータに導かれる油圧を低下させる吸気側電磁弁と、クランクシャフトに対する排気側カムシャフトの位相角を油圧の上昇に応動して排気弁の開閉時期が遅れる方向に変える排気側油圧アクチュエータと、その非通電時に排気側油圧アクチュエータに導かれる油圧を低下させる排気側電磁弁とを備える。

【００１０】請求項４記載の発明は、低回転高負荷時から高回転時に変わる運転条件で、吸気弁の開閉時期を切換えた後に排気弁の開閉時期を切換える制御手段を備える。

【００１１】

【作用】低回転低負荷時に排気弁の開閉時期を進ませるとともに、吸気弁の開閉時期を遅らせて、バルブオーバラップを小さくすることにより、排気ポートからシリンダへの排気の吹き返しを抑えられ、残留ガス率を低下させて燃焼を安定させるとともに、アイドル安定性を高められ、燃費の低減がはかれる。

【００１２】低回転高負荷時に、吸気弁の開閉時期を進ませることにより、シリンダに吸入された混合気が吸入行程の下死点付近で吸気ポートに吐き出されることを抑制して、吸気充填効率を高められる。このとき、排気弁の開閉時期も進ませることにより、バルブオーバラップが大きくなり過ぎることを回避し、残留ガスを低下させ、発生トルクを高められる。

【００１３】高回転時に、吸気弁の開閉時期を遅らせることにより、吸気の慣性過給効果を利用して吸気充填効率を高められる。

【００１４】請求項２記載の発明においては、クランクシャフトに対する吸気側カムシャフトの位相角の最大変位量を、排気側カムシャフトの位相角の最大変位量より小さく設定することにより、吸気弁と排気弁の開閉時期を共に遅らせる高回転時に、バルブオーバラップを大きくすることができる。これにより、排気管内に生じる負圧波により排気の掃気効果が得られ、排気の押し出し損失を低減して出力向上がはかれる。すなわち、排気行程の後半は排気管を移動する排気ガスにより負圧が生じるとともに、オーバラップ期間中は吸気流がシリンダ内に流入することにより、排気ガスの掃気効果が高められる。

【００１５】請求項３記載の発明においては、バルブタイミング調整機構に導かれる油圧を低下させて、吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を進ませる構成としたため、始動時を含めてオイルポンプの吐出油圧が低い低回転低負荷時に、バルブオーバラップを小さくする切換え応答性を確保することが可能となり、始動性およびアイドル安定性を維持できる。また、油圧系統の故障により十分な油圧が発生しない場合も、吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を進ませて、バルブオーバラップを小さくすることにより、安定した運転性を確保することができる。

【００１６】請求項４記載の発明においては、低回転高負荷時から高回転時に変わる運転条件で、吸気弁の開閉時期を切換えた後に排気弁の開閉時期を切換える構成としたため、２つの電磁弁が同時に通電されて、各バルブタイミング調整機構に導かれる油圧が一瞬高まる油撃作用が発生することを回避し、潤滑系統に損傷等を来すことを防止する。

【００１７】

【実施例】図２は本発明の一実施例の機械的構成を示す。

【００１８】図中、２ｉは吸気弁（図示せず）を開閉駆動するカムシャフト、２ｅは排気弁（図示せず）を開閉駆動するカムシャフト、３ｉ，３ｅはタイミングベルト１６を介してクランクシャフト（図示せず）からの回転力が伝達されるカムプーリである。

【００１９】各バルブタイミング調整機構１ｉ，１ｅは各カムシャフト２ｉ，２ｅと各カムプーリ３ｉ，３ｅの間に設けられ、運転条件に応じて両者の位相角度を変えて吸気弁と排気弁の開閉時期を独立して変えるようになっている。

【００２０】各カムシャフト２ｉ，２ｅの端部は筒形の各インナハウジング４ｉ，４ｅが各ボルト１５ｉ，１５ｅを介して締結される。

【００２１】各インナハウジング４ｉ，４ｅの外周に回転可能に嵌合する筒形のアウタハウジング５ｉ，５ｅが設けられ、各アウタハウジング５ｉ，５ｅに各カムプーリ３ｉ，３ｅが一体形成される。

【００２２】各インナハウジング４ｉ，４ｅと各アウタハウジング５ｉ，５ｅの間にはリング状の各ヘリカルギア６ｉ，６ｅが介装される。ヘリカルギア６ｉの内外周に各ヘリカルスプライン１７ｉ，１８ｉが、ヘリカルギア６ｅの内外周にヘリカルスプライン１７ｅ，１８ｅとがそれぞれ形成される。各ヘリカルスプライン１７ｉ，１７ｅがインナハウジング４ｉ，４ｅの外周と噛合い、各ヘリカルスプライン１８ｉ，１８ｅがアウタハウジング５ｉ，５ｅの内周と噛合い、各ヘリカルギア６ｉ，６ｅが軸方向に移動するのに伴い各アウタハウジング５ｉ，５ｅに対して各インナハウジング４ｉ，４ｅが相対回転し、各カムプーリ３ｉ，３ｅに対する各カムシャフト２ｉ，２ｅの回転方向の位相角が変化する。

【００２３】ヘリカルギア６ｉの各ヘリカルスプライン１７ｉ，１８ｉに対して、ヘリカルギア６ｅのヘリカルスプライン１７ｅ，１８ｅが逆方向に捩られて形成される。これにより、各ヘリカルギア６ｉ，６ｅが所期位置からリターンスプリング１３ｉ，１３ｅに抗して図中右方向に移動することにより互いに逆方向に回転し、吸気側カムシャフト２ｉは吸気弁の開閉時期を進角させる方向に回転し、排気側カムシャフト２ｅは排気弁の開閉時

期を遅角させる方向に回転するようになっている。

【００２４】各ヘリカルギア６ｉ，６ｅと各インナハウジング４ｉ，４ｅの間には各リターンスプリング１３ｉ，１３ｅが介装され、各リターンスプリング１３ｉ，１３ｅにより各ヘリカルギア６ｉ，６ｅが図中左方向に付勢されて、初期位置に保持される。

【００２５】インナハウジング４ｉ，４ｅとアウタハウジング５ｉ，５ｅとヘリカルギア６ｉ，６ｅの間には油圧室１２ｉ，１２ｅが画成される。油圧室１２ｉ，１２ｅに導かれる油圧力が所定値を越えて上昇すると、各ヘリカルギア６ｉ，６ｅはリターンスプリング１２ｉ，１２ｅを圧縮しながら図中右方向に移動する。

【００２６】これにより、各ヘリカルギア６ｉ，６ｅが初期位置にあるときは、図３に実線で示すように、吸気弁の開閉時期が遅れるとともに、排気弁の開閉時期が進められ、各ヘリカルギア６ｉ，６ｅが最大に変位したときは、図３に破線で示すように、吸気弁の開閉時期が進められるとともに、排気弁の開閉時期が遅れる。

【００２７】クランクシャフトに対する吸気側カムシャフト２ｉの位相角の最大変位量θｉは、排気側カムシャフト２ｅの位相角の最大変位量θｅより所定量だけ小さく設定される。

【００２８】各油圧室１２ｉ，１２ｅは各カムシャフト２ｉ，２ｅの内部に形成された各軸孔２１ｉ，２１ｅと、シリンダヘッド２２に形成されたオイルギャラリ２３と、オリフィス２６と、シリンダブロック２４に形成されたメインギャラリ２５を介してオイルポンプ２９からの吐出油圧が導入される。

【００２９】各カムシャフト２ｉ，２ｅの他端にはエンジン運転条件に応じて開閉制御される電磁弁７ｉ，７ｅが設けられる。各電磁弁７ｉ，７ｅは非通電時に図のように各軸孔２１ｉ，２１ｅを開いて各油圧室１２ｉ，１２ｅに導かれる油圧を低下させ、通電時に各軸孔２１ｉ，２１ｅを閉塞して各油圧室１２ｉ，１２ｅに導かれる油圧を高めるようになっている。

【００３０】各バルブタイミング調整機構１ｉ，１ｅの制御手段として、各電磁弁７ｉ，７ｅの通電を制御する通電コントロールユニット３１が設けられる。

【００３１】コントロールユニット３１は、エンジンの回転信号、吸入空気量信号、水温信号、スロットルバルブスイッチ信号等を入力し、これらエンジンの運転条件に応じて各電磁弁７ｉ，７ｅの通電を制御して、各バルブタイミング調整機構１ｉ，１ｅを作動させるようになっている。

【００３２】図１に示すように、コントロールユニット３１は、アイドル時を含む低回転低負荷時に各電磁弁７ｉ，７ｅを共にＯＦＦとして、吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を進ませて、吸気弁と排気弁が同時に開弁するバルブオーバラップを極小とし、低回転高負荷時に電磁弁７ｉをＯＮとし、電磁弁７ｅをＯＦＦとして、吸気弁の開閉時期を進ませるとともに、排気弁の開閉時期を進ませて、バルブオーバラップを中間値とし、高回転時に電磁弁７ｉをＯＦＦとし、電磁弁７ｅをＯＮとして、吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を遅らせて、バルブオーバラップを大きくするように各バルブタイミング調整機構１ｉ，１ｅを駆動する。

【００３３】コントロールユニット３１は、吸気弁または排気弁の開閉時期を切換える運転時に、吸気側電磁弁７ｉと排気側電磁弁７ｅの少なくとも一方の通電を停止する。すなわち、電磁弁７ｉがＯＮとなる低回転高負荷時から、電磁弁７ｅがＯＮとなる高回転時へと切換えられる際に、電磁弁７ｉを先にＯＦＦにしてから、電磁弁７ｅをＯＮにする。逆に、電磁弁７ｅがＯＮとなる高回転時から、所定の時間差をもって電磁弁７ｉがＯＮとなる低回転高負荷時へと切換えられる際に、電磁弁７ｅを先にＯＦＦにしてから、所定の時間差をもって電磁弁７ｉをＯＮにする。

【００３４】次に、作用について説明する。

【００３５】低回転低負荷時にバルブオーバラップを極小とすることにより、排気ポートからシリンダへの排気の吹き返しを抑えて、残留ガス率を低下させられる。この結果、燃焼が安定して、燃費の低減がはかれるとともに、アイドル安定性を高められる。

【００３６】また、各バルブタイミング調整機構１ｉ，１ｅは各油圧室１２ｉ，１２ｅに導かれる油圧が低下する初期位置で、吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を進ませる構成としたため、始動時を含めてオイルポンプの吐出油圧が低い低回転低負荷時に、切換え応答性を確保することが可能となり、始動性およびアイドル安定性を維持できる。また、油圧系統の故障により十分な油圧が発生しない場合も、吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を進ませて、バルブオーバラップを小さくすることにより、安定した運転性を確保することができる。

【００３７】低回転高負荷時に、吸気弁の開閉時期を進ませることにより、シリンダに吸入された混合気が吸入行程の下死点付近で吸気ポートに吐き出されることを抑制して、吸気充填効率を高められる。このとき、排気弁の開閉時期も進ませることにより、バルブオーバラップが大きくなり過ぎることを回避し、残留ガスを低下させ、発生トルクを高められる。

【００３８】高回転時に、吸気弁の開閉時期を遅らせることにより、吸気の慣性過給を利用して吸気充填効率を高められる。

【００３９】クランクシャフトに対する吸気側カムシャフト２ｉの位相角の最大変位量θｉは、排気側カムシャフト２ｅの位相角の最大変位量θｅより所定量だけ小さく設定されているため、吸気弁と排気弁の開閉時期を共に遅らせる高回転時に、バルブオーバラップを大きくす

ることができる。高回転時にバルブオーバラップを大きくすることにより、排気管内に生じる負圧波による掃気効果が得られ、排気の押し出し損失を低減して出力向上がはかれる。すなわち、排気行程の後半は排気管を移動する排気ガスにより負圧が生じるとともに、オーバラップ期間中は吸気流がシリンダ内に流入することにより、排気ガスの掃気効果が高められる。

【００４０】吸気弁または排気弁の開閉時期を切換える運転時に、吸気側電磁弁７ｉと排気側電磁弁７ｅの少なくとも一方の通電を停止するため、吸気側電磁弁７ｉと排気側電磁弁７ｅが同時に通電されて、各バルブタイミング調整機構１ｉ，１ｅに導かれる油圧が一瞬高まる油撃作用が発生することを回避し、潤滑系統に損傷等を来すことを防止する。

【００４１】

【発明の効果】以上説明したように本発明は、吸気弁を開閉駆動する吸気側カムシャフトと、排気弁を開閉駆動する排気側カムシャフトと、クランクシャフトに対する吸気側カムシャフトと排気側カムシャフトの位相角を独立して変えるバルブタイミング調整機構と、エンジンの運転条件を検出する手段と、エンジンの運転条件に応じてバルブタイミング調整機構を駆動する制御手段とを備えたエンジンの可変バルブタイミング装置にあって、制御手段は、低回転低負荷時に吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を進ませ、低回転高負荷時に吸気弁の開閉時期を進ませるとともに、排気弁の開閉時期を進ませ、高回転時に吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を遅らせるようにバルブタイミング調整機構を駆動する構成としたため、広い運転範囲に渡って吸排気のタイミングを適正に制御して、低中回転時のトルク向上と、高回転時の出力向上を両立することができる。また、エンジン運転条件に応じて複数のカムを選択的に切換える弁作動調整機構を備える従来装置に比べて、同等の性能を得ながら、大幅なコストダウンがはかれる。

【００４２】請求項２記載の発明においては、クランクシャフトに対する吸気側カムシャフトの位相角の最大変位量を、排気側カムシャフトの位相角の最大変位量より小さく設定することにより、吸気弁と排気弁の開閉時期を共に遅らせる高回転時に、バルブオーバラップを大きくすることができる。これにより、排気管内に生じる負圧波により排気の掃気効果が得られ、排気の押し出し損失を低減して出力向上がはかれる。

【００４３】請求項３記載の発明においては、バルブタイミング調整機構に導かれる油圧を低下させて、吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を進ませる構成としたため、始動時を含めてオイルポンプの吐出油圧が低い低回転低負荷時に、バルブオーバラップを小さくする切換え応答性を確保することが可能となり、始動性およびアイドル安定性を維持できる。また、油圧系統の故障により十分な油圧が発生しない場合も、吸気弁の開閉時期を遅らせるとともに、排気弁の開閉時期を進ませて、バルブオーバラップを小さくすることにより、安定した運転性を確保することができる。

【００４４】請求項４記載の発明においては、低回転高負荷時から高回転時に変わる運転条件で、吸気弁の開閉時期を切換えた後に排気弁の開閉時期を切換える構成としたため、２つの電磁弁が同時に通電されて、各バルブタイミング調整機構に導かれる油圧が一瞬高まる油撃作用が発生することを回避し、潤滑系統に損傷等を来すことを防止する。

【図面の簡単な説明】

【図１】本発明の実施例において、バルブタイミングを切換える制御内容を示す特性図。

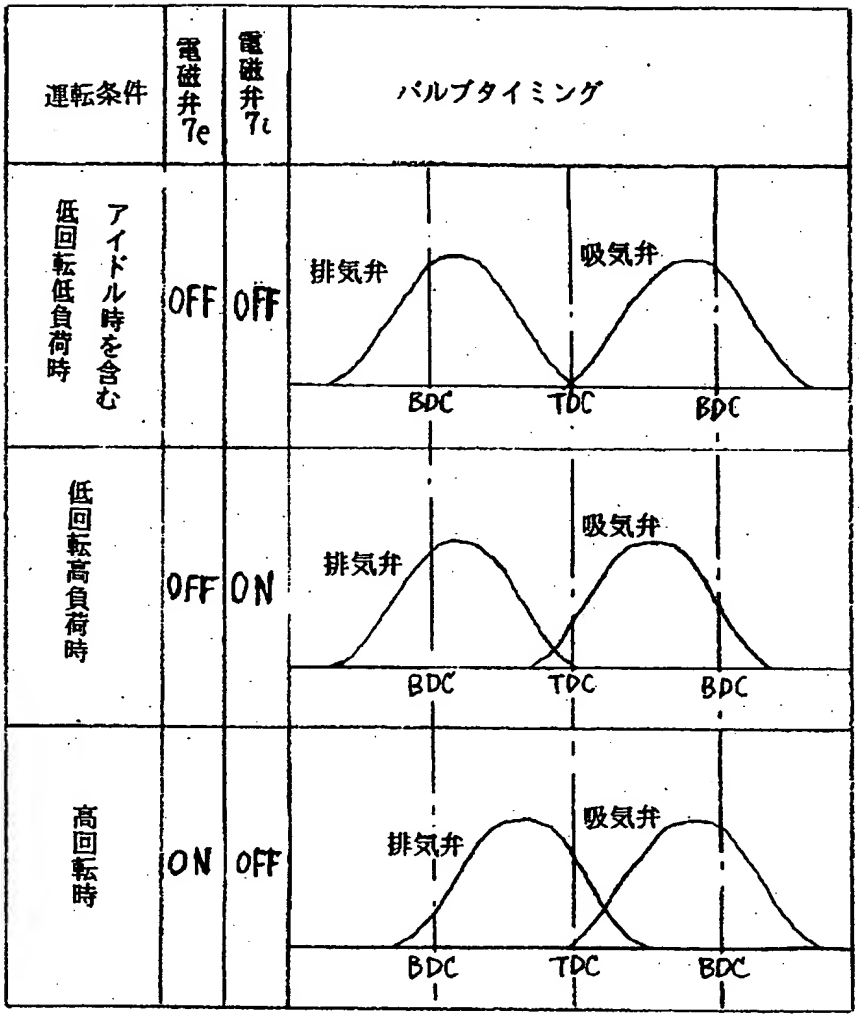
【図２】同じく本発明の実施例を示す機械的構成図。

【図３】同じくバルブタイミングの切換え特性図。

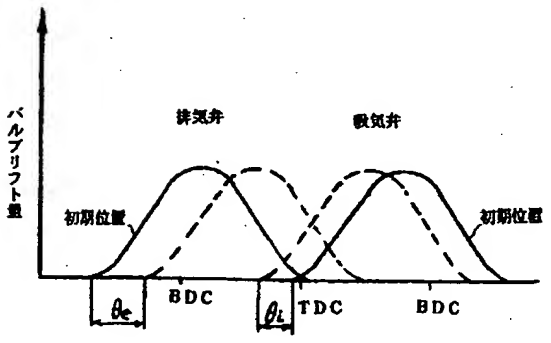
【符号の説明】

１ｉ　バルブタイミング調整機構
１ｅ　バルブタイミング調整機構
２ｉ　吸気側カムシャフト
２ｅ　排気側カムシャフト
７ｉ　吸気側電磁弁
７ｅ　排気側電磁弁
１２ｉ　油圧室
１２ｅ　油圧室
１３ｉ　リターンスプリング
１３ｅ　リターンスプリング
３１　コントロールユニット

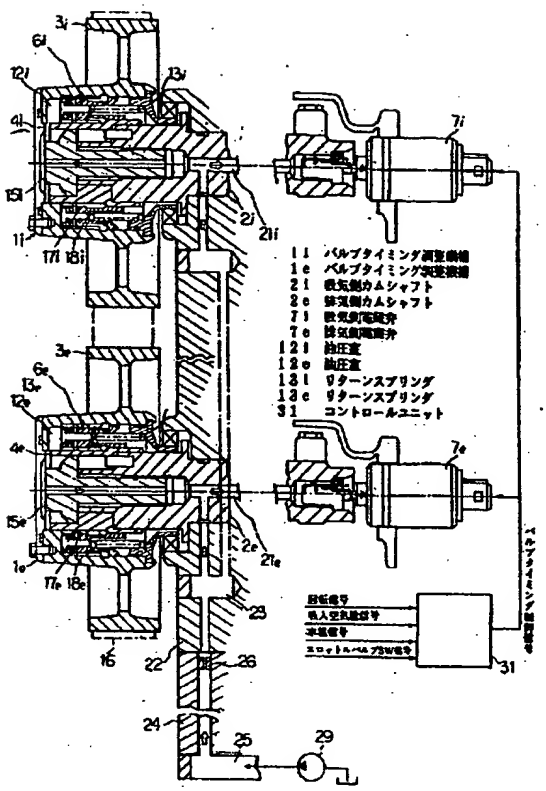
【図1】


運転条件
電磁弁 7e
電磁弁 7i
バルブタイミング
アイドル時を含む低回転低負荷時
OFF
OFF
排気弁
吸気弁
BDC
TDC
BDC
低回転高負荷時
OFF
ON
排気弁
吸気弁
BDC
TDC
BDC
高回転時
ON
OFF
排気弁
吸気弁
BDC
TDC
BDC

【図3】


バルブリフト量
排気弁
吸気弁
初期位置
初期位置
θe
BDC
θi
TDC
BDC

【図２】


11 バルブタイミング調整機構
1e バルブタイミング調整機構
21 吸気側カムシャフト
2e 排気側カムシャフト
71 吸気側電磁弁
7e 排気側電磁弁
121 油圧室
12e 油圧室
131 リターンスプリング
13e リターンスプリング
31 コントロールユニット
31

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	C	6965-3G	Request for examination: not requested
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F02D 13/02	G	7049-3G	Number of claims: 4
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(54) Title of the Invention:

VARIABLE VALVE TIMING DEVICE FOR ENGINE

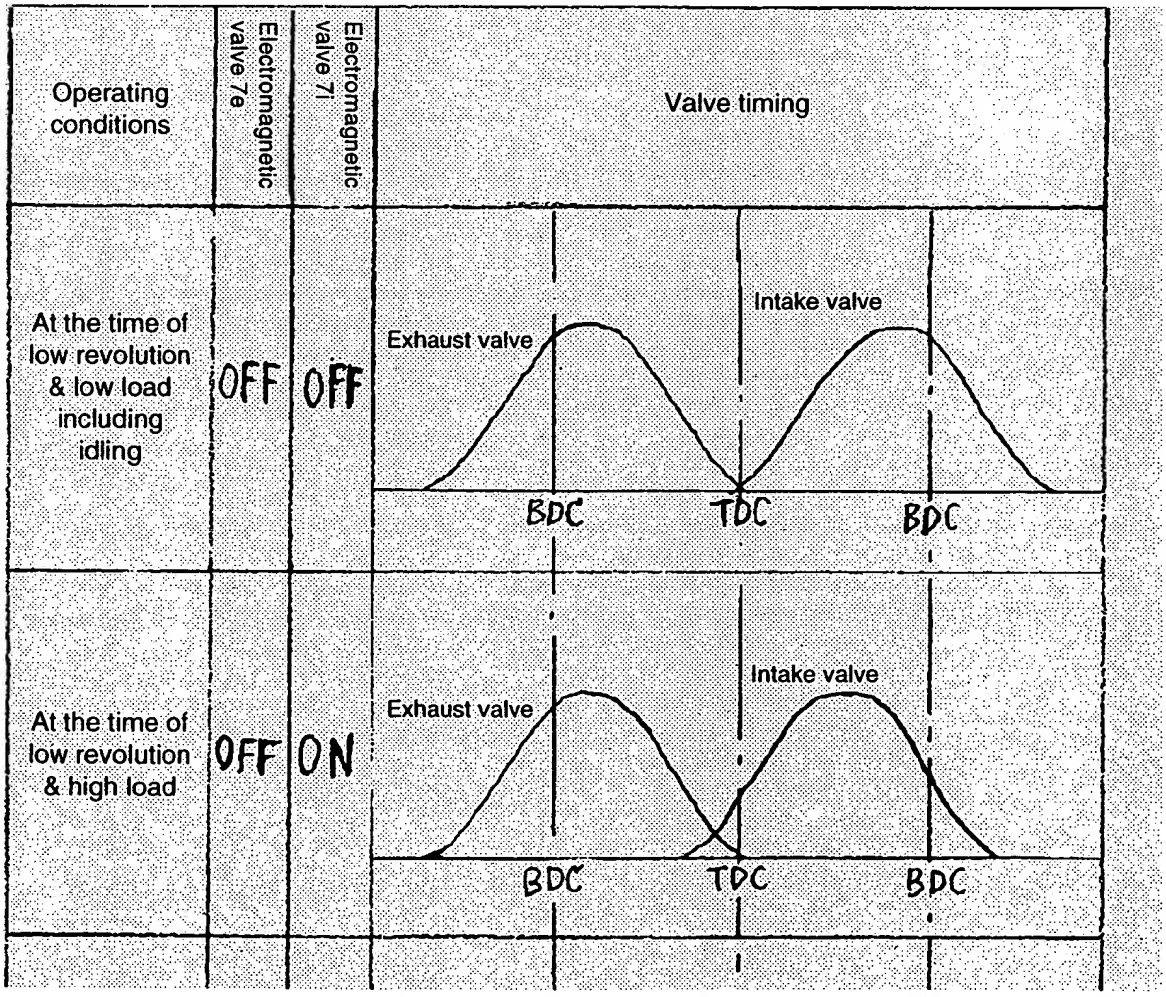
(57) Abstract

Objective:

To provide a device to properly control intake and exhaust timing using a valve timing adjustment mechanism to change the phase angle relative to a crank shaft.

Construction:

[The present invention] is provided with a valve timing adjustment mechanism to independently change the phase angle of an intake-side camshaft and an exhaust-side camshaft relative to a crank shaft, wherein a control unit is constructed by driving the valve timing adjustment mechanism to delay the opening/closing timing of the intake valve at low rpm and low load, and concurrently to advance the opening/closing timing of the exhaust valve; to advance the opening/closing timing of the intake valve at low rpm and high load, and concurrently to advance the opening/closing timing of the exhaust valve; to delay the opening/closing timing of the intake valve at high rpm, and concurrently to delay the opening/closing timing of the exhaust valve.



What is claimed is:

1. A variable valve timing device for an engine, wherein, the variable valve timing device comprises a variable valve timing device for an engine provided with an intake-side camshaft to drive the opening/closing of an intake valve, an exhaust-side camshaft to drive the opening/closing of an exhaust valve, a valve timing adjustment mechanism to independently change the phase angle of the intake-side camshaft and the exhaust-side camshaft relative to a crank shaft, a means to detect operating conditions for the engine and a control means to drive the valve timing adjustment mechanism according to the engine operating conditions, wherein the control means is constructed by driving the valve timing adjustment mechanism to delay the opening/closing timing of the intake valve at low rpm and low load, and concurrently to advance the opening/closing timing of the exhaust valve; to advance the opening/closing timing of the intake valve at low rpm and high load, and concurrently to advance the opening/closing timing of the exhaust valve; and to delay the opening/closing timing of the intake valve at high rpm, and concurrently to delay the opening/closing timing of the exhaust valve.

2. The variable valve timing device for the engine according to Claim 1, wherein, in the valve timing adjustment mechanism, maximum displacement of the phase angle of the intake-side camshaft is set to be smaller than that of the exhaust-side camshaft relative to the crank shaft.

3. The variable valve timing device for the engine according to Claim 1, wherein, The variable valve timing device for the engine is provided with an intake-side hydraulic actuator to change the phase angle of the intake-side camshaft relative to the crank shaft to a direction for advancing the opening/closing timing of the intake valve by reacting to a rise in hydraulic pressure; an intake-side electromagnetic valve to lower the hydraulic pressure led by the intake-side hydraulic actuator when there is non-electric conduction; an exhaust-side hydraulic actuator to change the phase angle of the exhaust-side camshaft relative to the crank shaft to a direction for delaying the opening/closing timing of the exhaust valve by reacting to a rise in hydraulic pressure; and an exhaust-side electromagnetic valve to lower the hydraulic pressure led by the exhaust-side hydraulic actuator when there is non-electric conduction.

4. The variable valve timing device for the engine according to Claim 3, wherein, The variable valve timing device for the engine is provided with the control means to switch the opening/closing timing of the exhaust valve after switching the opening/closing timing of the intake valve under operating conditions to shift from low rpm and high load to high rpm.

DETAILED DESCRIPTION OF THE INVENTION

[0001]

Industrial field:

The present invention relates to a variable valve timing device to change the phase angle relative to a crank shaft and to control the opening/closing timing of intake and exhaust valves according to engine operating conditions.

[0002]

Prior art and problem thereof:

This type of variable valve timing device, for example, is disclosed in Japanese Utility Model Application Laid-Open No. Hei 2-72305, provided with a valve timing adjustment mechanism where the connection of a cam pulley and a camshaft via a helical gear reacting to hydraulic pressure and the control of the hydraulic pressure operated by the helical gear according to the engine operation state result in the movement of the helical gear in a direction of the axis of revolution and the relative revolution of the crank shaft and the camshaft.

[0003]

However, the valve timing adjustment mechanism is conventionally established only in the intake-side camshaft, and is designed so that lessening the valve overlap at low rpm and low load results in lowering the remaining gas ratio and stabilizes combustion. In the meantime, advancing the opening/closing timing of the intake valve at low rpm and high load restrains the gas mixture intaken by a cylinder discharged into an intake port in the vicinity of bottom dead center during the intake process and the enhancement of the intake filling efficiency.

[0004]

In a device for adjusting only the opening/closing timing of the intake valve, for example, in order to advance the closing timing of the intake valve at low rpm and high load, if the opening/closing timing is advanced, valve overlap becomes excessive, the remaining gas ratio increases and combustion is diminished. Further, it is impossible to delay the opening/closing timing of the intake valve while the valve overlap is increased at high rpm, with the problem that sufficient output cannot be obtained.

[0005]

Further, a device provided with a valve operation adjustment mechanism to selectively switch between multiple cams according to engine operating conditions and controlling the intake/exhaust timing or intake/exhaust volume has been conventionally known. However, in this case, the valve operation adjustment mechanism to switch between the

cams by corresponding to the intake and exhaust valves in each cylinder has to be established, leading to the problem of increased cost (reference is made, for example, to Japanese Patent Application Laid-Open Nos. Sho 63-167016 and Sho 63-57805).

[0006]
The present invention, focuses on the problem, and has the objective of providing a device to control the intake/exhaust timing using a valve timing adjustment mechanism to change the phase angle relative to a crank shaft.

[0007]

Problem Resolution Means:

The present invention is a variable valve timing device for an engine provided with an intake-side camshaft to drive the opening/closing of an intake valve, an exhaust-side camshaft to drive the opening/closing of an exhaust valve, a valve timing adjustment mechanism to independently change the phase angle of the intake-side camshaft and the exhaust-side camshaft relative to a crank shaft, a means to detect operating conditions for the engine and a control means to drive the valve timing adjustment mechanism according to the engine operating conditions, wherein the control means is constructed by driving the valve timing adjustment mechanism to delay the opening/closing timing of the intake valve at low rpm and low load, and concurrently to advance the opening/closing timing of the exhaust valve; to advance the opening/closing timing of the intake valve at low rpm and high load, and concurrently to advance the opening/closing timing of the exhaust valve; and to delay the opening/closing timing of the intake valve at high rpm, and concurrently to delay the opening/closing timing of the exhaust valve.

[0008]

In the invention according to Claim 2, in the valve timing adjustment mechanism, maximum displacement of the phase angle of the intake-side camshaft is set to be smaller than that of the exhaust-side camshaft relative to the crank shaft.

[0009]

The invention according to Claim 3 is provided with an intake-side hydraulic actuator to change the phase angle of the intake-side camshaft relative to the crank shaft to a direction for advancing the opening/closing timing of the intake valve by reacting to a rise in hydraulic pressure; an intake-side electromagnetic valve to lower the hydraulic pressure led by the intake-side hydraulic actuator when there is non-electric conduction; an exhaust-side hydraulic actuator to change the phase angle of the exhaust-side camshaft relative to the crank shaft to a direction for delaying the opening/closing timing of the exhaust valve by reacting to a rise in hydraulic pressure; and an exhaust-side electromagnetic valve to lower the hydraulic pressure led by the exhaust-side hydraulic actuator when there is non-electric conduction.

[0010]

The invention according to Claim 4 is provided with a control means to switch the opening/closing timing of the exhaust valve after switching the opening/closing timing of the intake valve under operating conditions to shift from low rpm and high load to high rpm.

[0011]

Operation:

Advancing the opening/closing timing of the exhaust valve at low rpm and low load, and concurrently delaying the opening/closing timing of the intake valve and lessening the valve overlap result in restraining exhaust [gas] blown back into a cylinder from the exhaust port, reduces the remaining gas ratio and stabilizes combustion, and at the same time enhances idling stability reduces fuel costs.

[0012]

Advancing the opening/closing timing of the intake valve at low rpm and high load restrains the gas mixture intaken by the cylinder from being discharged into an intake port in the vicinity of a bottom dead center during the intake process and enhances intake filling efficiency. Also advancing the opening/closing timing of the exhaust valve avoids excessive valve overlap, reduces the remaining gas and increases the generated torque.

[0013]

Delaying the opening/closing of the intake valve at high rpm enhances the intake filling efficiency by utilizing the intake inertia supercharging effect.

[0014]

In the invention according to Claim 2, setting the maximum displacement of the phase angle of the intake-side camshaft to be smaller than that of the exhaust-side camshaft relative to the crank shaft increases valve overlap at high rpm when the opening/closing timing of both the intake valve and the exhaust valve are delayed, supercharging the exhaust [gas] due to a negative pressure wave generated within the exhaust pipe, reducing exhaust [gas] loss from being forced out, with improved output. In other words, negative pressure is generated due to exhaust gas migration within the exhaust pipe during the second half of the exhaust process. At the same time, inflow of the intake airflow into the cylinder during the overlap period enhances the supercharged effect of the exhaust gas.

[00015]

The invention according to Claim 3 is constructed by lowering the hydraulic pressure led by the valve timing adjustment mechanism, delaying the opening/closing timing of the intake valve, and concurrently advancing the opening/closing timing of the exhaust valve, making it possible to secure the switch response to lessen the valve overlap at low rpm and low load when the discharged hydraulic pressure of the oil pump is low including when there is starting, and the startability and the idling stability can be maintained. Further, even when a failure of the hydraulic system causes insufficient generation of hydraulic pressure, delaying the opening/closing timing of the intake valve, and concurrently advancing the opening/closing timing of the exhaust valve and lessening the valve overlap enable securing stable operation.

[0016]

The invention according to Claim 4 is constructed by switching the opening/closing timing of the exhaust valve after switching the opening/closing timing of the intake valve under the operating conditions to shift from low rpm and high load to high rpm, avoiding the simultaneous electric conduction of two electromagnetic valves and the generation of an oil hammer effect where the hydraulic pressure led by each valve timing adjustment mechanism instantaneously ascends, preventing damage to the lubricating-system.

[0017]

Embodiment:

Fig. 2 shows the mechanical construction of an embodiment of the present invention.

[0018]

In the diagram, symbol 2i represents a camshaft to drive the opening/closing of an intake valve (not shown), 2e represents a camshaft to drive the opening/closing of an exhaust valve (not shown), and 3i and 3e are cam pulleys where torque from a crank shaft (not shown) is transmitted via a timing belt 16.

[0019]

Valve timing adjustment mechanisms 1i and 1e are established between the camshafts 2i and 2e and the cam pulleys 3i and 3e, respectively, and they are designed to independently change the opening/closing timing of the intake valve and the exhaust valve by changing the phase angle of both according to the operating conditions.

[0020]

Barrel inner housings 4i and 4e are fastened to the ends of the camshafts 2i and 2e via bolts 15i and 15e, respectively.

[0021]

Barrel outer housings 5i and 5e are rotatably fit into the outer circumferences of the inner housings 4i and 4e, respectively, and the cam pulleys 3i and 3e are integrally formed to the outer housings 5i and 5e, respectively.

[0022]

Ring-state helical gears 6i and 6e are respectively disposed between the inner housings 4i and 4e and the outer housings 5i and 5e. Helical splines 17i and 18i are formed around the inner and outer circumferences of the helical gear 6i, respectively, and helical splines 17e and 18e are formed around the inner and outer circumferences of the helical gear 6e, respectively. The helical splines 17i and 17e are engaged with the outer circumferences of the inner housings 4i and 4e, respectively; the helical splines 18i and 18e are engaged with the inner circumferences of the outer housings 5i and 5e, respectively; accompanied with the movement of the helical gears 6i and 6e axially, the inner housings 4i and 4e are relatively rotated with respect to the outer housings 5i and 5e, respectively; and the phase angles of the camshafts 2i and 2e in the rotative directions relative to the cam pulleys 3i and 3e are changed.

[0023]
The helical splines 17e and 18e of the helical gear 6e are respectively twisted in opposite directions relative to the helical splines 17i and 18i of the helical gear 6i, and are designed so that the movement of the helical gears 6i and 6e from the desired positions [sic.] toward the right direction in the drawing resisted by return springs 13i and 13e results in rotating to the opposite direction from each other, and rotating the intake-side camshaft 2i in a direction for advancing the opening/closing timing of the intake valve, and the exhaust-side camshaft 2e in a direction for delaying the opening/closing timing of the exhaust valve.

[0024]

The return springs 13i and 13e are disposed between the helical gears 6i and 6e and the inner housings 4i and 4e, respectively, with the return springs 13i and 13e energizing the helical gears 6i and 6e toward the left direction in the diagram, maintaining the initial position [sic.], respectively.

[0025]

Hydraulic chambers 12i and 12e are partitioned within the inner housings 4i and 4e, the outer housings 5i and 5e and the helical gears 6i and 6e, respectively. When the hydraulic pressure to the hydraulic chambers 12i and 12e ascends over a pre-determined value, the helical gears 6i and 6e move toward the right direction in the diagram while compressing the return springs 12i and 12e, respectively.

[0026]

With this design, when the helical gears 6i and 6e are situated at the initial positions [sic.], as shown by the solid line in Fig. 3, the opening/closing timing of the intake valve is delayed, and concurrently, the opening/closing timing of the exhaust valve is advanced; and when the helical gears 6i and 6e are displaced at maximum, as shown by the broken line in Fig. 3, the opening/closing timing of the intake valve is advanced. Concurrently, the opening/closing timing of the exhaust valve is delayed.

[0027]

The maximum displacement θi of the phase angle of the intake-side camshaft 2i relative to the crank shaft is set to be smaller than a maximum displacement θe of the phase angle of the exhaust-side camshaft 2e by a pre-determined magnitude.

[0028]

The discharged hydraulic pressure from the oil pump 29 is induced into the hydraulic chambers 12i and 12e via axial holes 21i and 21e formed inside the camshafts 2i and 2e, an oil gallery 23 formed in a cylinder head 22, an orifice 26 and a main gallery 25 formed in a cylinder block 24, respectively.

[0029]

The electromagnetic valves 7i and 7e where the opening and closing are controlled according to the engine operating conditions are established at the other ends of the camshafts 2i and 2e, respectively. Electromagnetic valves 7i and 7e are designed such that the axial holes 21i and 21e are opened when there is non-electric conduction and the hydraulic pressure led to the hydraulic chambers 12i and 12e is lowered as shown in the diagram, and the axial holes 21i and 21e are blocked when there is electric conduction and the hydraulic pressure led to the hydraulic chambers 12i and 12e is increased, respectively.

[0030]

As a control means of the valve timing adjustment mechanisms 1i and 1e, electric conduction control unit 31 to control the electric conduction of the electromagnetic valves 7i and 7e is established, respectively.

[0031]

The control unit 31 enters an engine rpm signal, an intake air volume signal, a water temperature signal and a throttle valve switch signal, according to which operating conditions the electric conduction of the electromagnetic valves 7i and 7e are controlled, and the valve timing adjustment mechanisms 1i and 1e are operated.

[0032]

As shown in Fig. 1, the control unit 31 drives the valve timing adjustment mechanisms 1i and 1e to delay the opening/closing timing of the intake valve by turning OFF both the electromagnetic valves 7i and 7e at low rpm and low load including when there is idling, and concurrently, to advance the opening/closing timing of the exhaust valve, to set the valve overlap for simultaneously opening the intake valve and the exhaust valve to be minimum; to turn ON the electromagnetic valve 7i at low rpm and high load, to turn OFF the electromagnetic valve 7e and to advance the opening/closing timing of the intake valve, and concurrently to advance the opening/closing timing of the exhaust valve and to set the valve overlap to be a mean value; to turn OFF the electromagnetic valve 7i at high rpm, to turn ON the electromagnetic valve 7e and to delay the opening/closing timing of the intake valve, and concurrently to delay the opening/closing timing of the exhaust valve and to increase the valve overlap.

[0033]

The control unit 31 halts the electric conduction of at least either the intake-side electromagnetic valve 7i or the exhaust-side electromagnetic valve 7e when there is operation to switch the opening/closing timing of the intake valve or the exhaust valve. In other words, when switching from low rpm and high load when the electromagnetic valve 7i is turned ON to high rpm when the electromagnetic valve 7e is turned ON, the electromagnetic valve 7i is turned OFF first, and then, the electromagnetic valve 7e is turned ON. Meanwhile, when switching from high rpm when the electromagnetic valve 7e is turned ON to low rpm and high load when the electromagnetic valve 7i is turned ON by having a pre-determined time difference, the electromagnetic valve 7e is turned OFF first, and then the electromagnetic valve 7i is turned ON after a pre-determined time difference has elapsed.

[0034]

The operation is described next.

[0035]

Setting the valve overlap to be minimum at low rpm and low load restrains exhaust [gas] blown back from the exhaust port into the cylinder, reduces the remaining gas ratio, stabilizing combustion reducing fuel costs. At the same time, idling stability is enhanced.

[0036]

Further, the valve timing adjustment mechanisms 1i and 1e are constructed by delaying the opening/closing timing of the intake valve at the initial position to lower the hydraulic pressure led to the hydraulic chambers 12i and 12e, respectively, and concurrently advancing the opening/closing timing of the exhaust valve, making it possible to secure the switch response at low rpm and low load when the discharged hydraulic pressure of the oil pump is low including when there is starting, and startability and idling stability can be maintained. Further, even when failure of the hydraulic system causes insufficient

generation of hydraulic pressure, delaying the opening/closing timing of the intake valve, and concurrently advancing the opening/closing timing of the exhaust valve and lessening the valve overlap enable securing stable startability.

[0037]

Advancing the opening/closing timing of the intake valve at low rpm and high load restrains the gas mixture intaken by the cylinder from being discharged into the intake port in the vicinity of bottom dead center during the intake process and increases intake filling efficiency. Also advancing the opening/closing timing of the exhaust valve avoids excessive valve overlap, reduces the amount of remaining gas and increases generated torque.

[0038]

Delaying the opening/closing timing of the intake valve at high rpm results in increasing the intake filling efficiency by utilizing the inertial supercharging of the intake.

[0039]

Since the maximum displacement θi of the phase angle of the intake-side camshaft 2i is set to be smaller than the maximum displacement θe of the phase angle in the exhaust-side camshaft 2e relative to the crank shaft by a pre-determined magnitude, the valve overlap can be increased at high rpm when the opening/closing timing of both the intake valve and the exhaust valve are delayed. Increasing the valve overlap at high rpm enables obtaining a supercharging effect due to a negative pressure wave generated within the exhaust pipe, reduces exhaust [gas] loss due to its being forced out and improves output. In other words, the negative pressure is generated due to exhaust gas migration within the exhaust pipe during the second half of the exhaust process; and inflow of the intake airflow into the cylinder during the overlap period results in increasing the supercharging effect of the exhaust gas.

[0040]

Electric conduction of at least either the intake-side electromagnetic valve 7i or the exhaust-side electromagnetic valve 7e is halted when there is operation to switch the opening/closing timing of the intake valve or the exhaust valve avoids simultaneous electric conduction of the intake-side electromagnetic valve 7i and the exhaust-side electromagnetic valve 7e and the generation of an oil hammer effect instantaneously ascending the hydraulic pressure to be led by the valve timing adjustment mechanisms 1i and 1e, and prevents damage to the lubricating-system, respectively.

[0041]

Efficacy of the Invention:

As described, the present invention is a variable valve timing device provided with an intake-side camshaft to drive the opening/closing of the intake valve, an exhaust-side camshaft to drive the opening/closing of the exhaust valve, a valve timing adjustment mechanism to independently change the phase angles of the intake-side camshaft and the exhaust-side camshaft relative the crank shaft, the means to detect the engine operating conditions and the control means to drive the valve timing adjustment mechanism according to the engine operating conditions, wherein the control means is constructed by driving the valve timing adjustment mechanism to delay the opening/closing timing of the intake valve at low rpm and low load, and concurrently to advance the opening/closing timing of the exhaust valve; to advance the opening/closing timing of the intake valve at low rpm and high load, and concurrently to advance the opening/closing of the exhaust valve; to delay the opening/closing timing of the intake valve at high rpm, and concurrently to delay the opening/closing timing of the exhaust timing, so the intake/exhaust timing is properly controlled throughout the wide operating range, and both the torque improvement when there is low and medium revolution and the output improvement at high rpm can occur together. Further, in comparison with the conventional device provided with a valve operation adjustment mechanism to selectively switch between multiple cams according to the engine operating conditions, while the same level of performance is obtained, drastic cost reduction can be realized.

[0042]

The invention according to Claim 2 sets the maximum displacement of the phase angle of the intake-side camshaft to be smaller than that of the exhaust-side camshaft relative to the crank shaft increases the valve overlap at high rpm when both the opening/closing timing of the intake valve and the exhaust valve are delayed, enabling obtaining a supercharging effect of exhaust [gas] due to the negative pressure wave generated within the exhaust pipe, reduces exhaust [gas] loss due to its being forced out and improved output.

[0043]

Since the invention according to Claim 3 is constructed by lowering the hydraulic pressure led by the valve timing adjustment mechanism and delaying the opening/closing timing of the intake valve, concurrently advancing the opening/closing timing of the exhaust valve, it is possible to secure the switch response to lessen the valve overlap at low rpm and low load when the discharged hydraulic pressure of the oil pump is low, including when there is starting, and startability and idling stability can be maintained. Even when a failure of the hydraulic system causes insufficient generation of hydraulic pressure, delaying the opening/closing timing of the intake valve, and concurrently advancing the opening/closing timing of the exhaust valve and lessening the valve overlap enables the securing of a stable operability.

[0044]

The invention according to Claim 4 is constructed by switching the opening/closing timing of the exhaust valve after switching the opening/closing timing of the intake valve under operating conditions to shift from low rpm and high load to high rpm, avoiding simultaneous electric conduction of two electromagnetic valves and the generation of an oil hammer effect where the hydraulic effect led by each valve timing adjustment mechanism instantaneously ascends, preventing damage to the lubricating system.

BRIEF DESCRIPTION OF DRAWING

Fig. 1 is a characteristic diagram showing control details to switch the valve timing in an embodiment of the present invention.

Fig. 2 is a mechanical block diagram showing an embodiment of the present invention.

Fig. 3 is a characteristic diagram of the valve timing switch showing an embodiment of the present invention.

Description of symbols:

1i valve timing adjustment mechanism
1e valve timing adjustment mechanism
2i intake-side camshaft
2e exhaust-side camshaft
7i intake-side electromagnetic valve
7e exhaust-side electromagnetic valve
12i hydraulic chamber
12e hydraulic chamber
13i return spring
13e return spring
control unit

Fig. 1

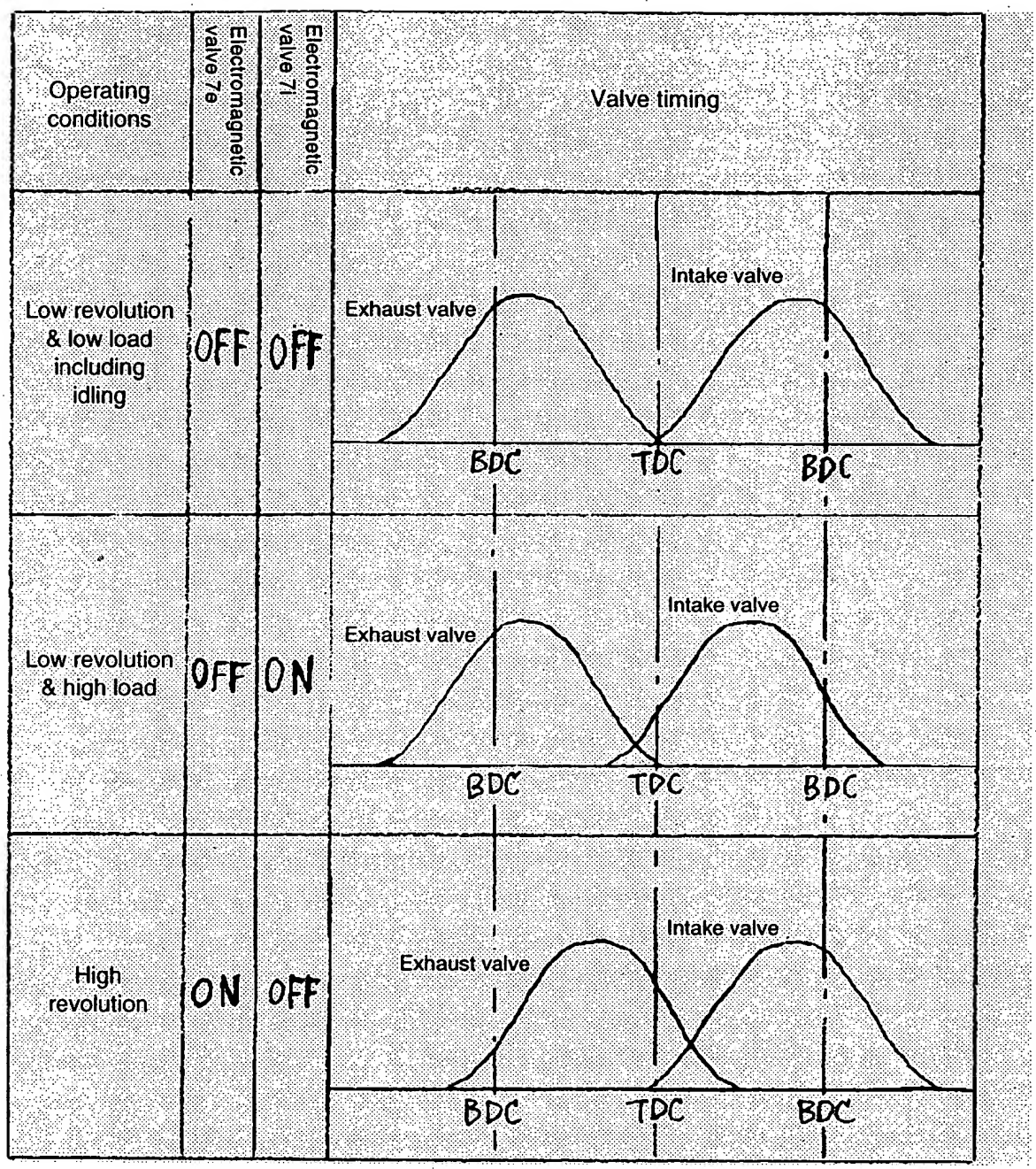

Operating conditions
Electromagnetic valve 7e
Electromagnetic valve 7i
Valve timing
Low revolution & low load including idling
OFF
OFF
Exhaust valve
Intake valve
BDC
TDC
BDC
Low revolution & high load
OFF
ON
Exhaust valve
Intake valve
BDC
TDC
BDC
High revolution
ON
OFF
Exhaust valve
Intake valve
BDC
TDC
BDC

Fig. 2

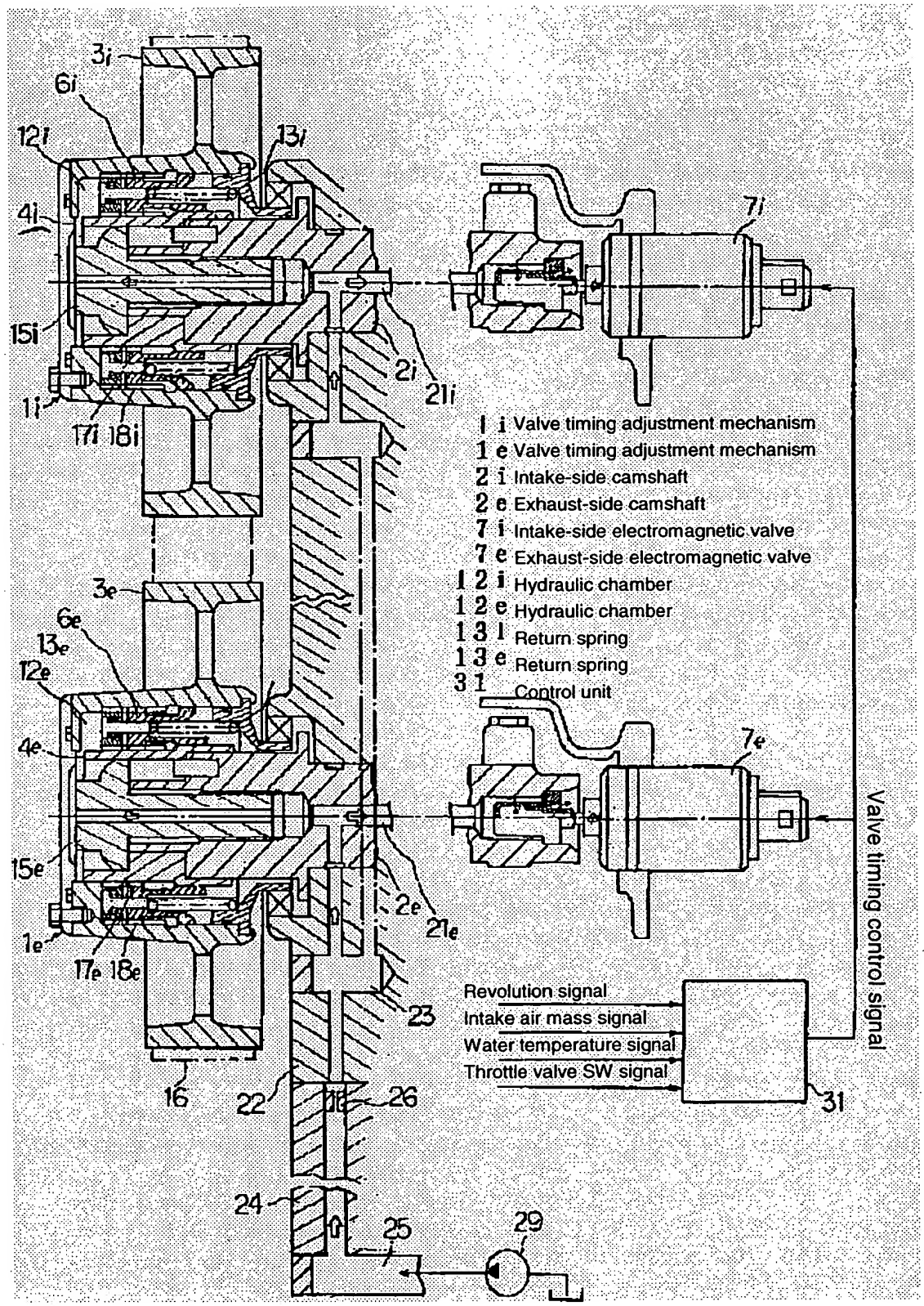
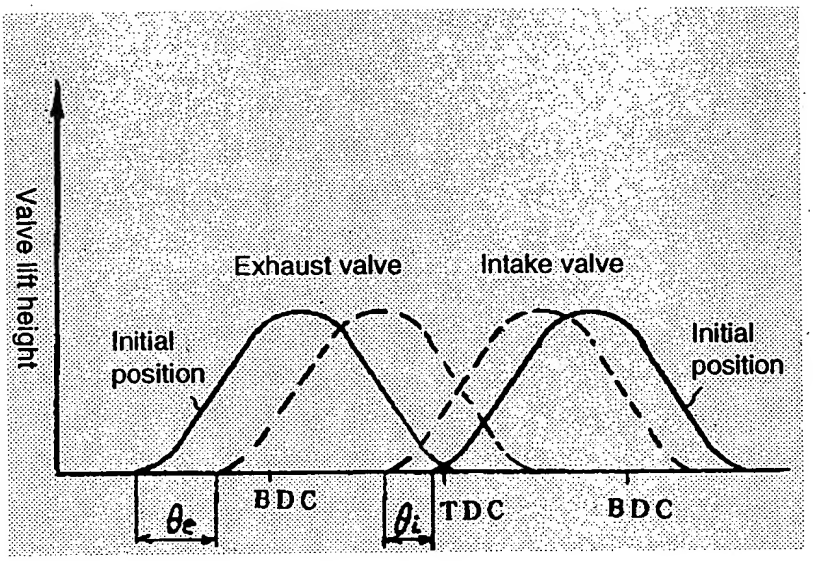

3i
6i
12i
13i
4i
15i
1i
17i
18i
2i
21i
7i
3e
6e
13e
12e
4e
15e
1e
17e
18e
2e
21e
7e
23
16
22
26
24
25
29
31
Revolution signal
Intake air mass signal
Water temperature signal
Throttle valve SW signal
Valve timing control signal
1 i Valve timing adjustment mechanism
1 e Valve timing adjustment mechanism
2 i Intake-side camshaft
2 e Exhaust-side camshaft
7 i Intake-side electromagnetic valve
7 e Exhaust-side electromagnetic valve
12 i Hydraulic chamber
12 e Hydraulic chamber
13 i Return spring
13 e Return spring
31 Control unit

Fig. 3


Valve lift height
Exhaust valve
Intake valve
Initial position
Initial position
BDC
TDC
BDC
θe
θi